PROJECT facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Petroleum Exploration and Production

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Improved 9-component Vertical Seismic Profiling

Shear wave data breakthrough

PARTNERS

Visos Energy Corporation
Austin, TX

The Bureau of Economic Geology at The University of Texas at Austin
Austin, TX

Vecta Technology, LP
Austin, TX

FIELD DEMONSTRATION SITE

Morrow Sand Reservoirs
CO, KS, & TX

RESEARCH SITE

The Bureau of Economic Geology at The University of Texas at Austin
Austin, TX

Test well locations.

Background/Problem

The Morrow Sand Trend of Colorado, Kansas, Oklahoma and Texas is from meandering fluvial channel reservoirs where drilling prospects and infill drilling sites are difficult to identify using conventional 3-D seismic survey methods that utilize only compressional (P) waves (waves traveling in the direction of the original seismic signal). Morrow sand reservoirs do not always generate sufficient reflected P-wave energy to produce an image clear enough to define the drilling target from seismic interpretation. Operators are often forced to select well locations without the aid of seismic technology, resulting in high-risk drilling programs and low drilling success rates.

Morrow reservoirs that generate weak P-wave seismic reflections often produce robust shear (S) wave reflections. P-waves and S-waves react to rock and fluid properties in a different way and provide different information about the rock system it is propagating through. The full vector (directional) properties of a seismic wavefield can be defined by three fundamental wave modes: the compressional (P) mode, the horizontal shear (SH) mode, and the vertical shear (SV) mode. Each wave mode creates a different induced particle-displacement motion into the rock system. The particle-displacement motions of the three wave modes are in-and-out, back-and-forth, and up-and-down respectively. Proper recording and interpretation of the combined P and S-wave seismic reflection activity results in improved Morrow stratigraphic imaging.

Project Description/Accomplishments

Visos Energy Corporation and the Bureau of Economic Geology, UT Austin conducted a field demonstration project to determine if shear wave seismic data could be used for imaging Morrow trend stratigraphy. Nine-component vertical seismic profile (9-C VSP) data were recorded at three separate test well locations across a large area of the Morrow trend. At each test well location, surface recorded 9-C VSP data were acquired using downhole 3-component (3-C) geophones and three distinct seismic sources: a vertical vibrator, an inline horizontal vibrator, and a crossline horizontal vibrator. The seismic wavefield generated by each vibrator was recorded as a separate field record by the downhole 3-C geophones to create the 9-C VSP data.

Using techniques developed by geoscientists at Visos and the BEG to correlate P and S-wave reflection data, the 9-C VSP data recorded at each test well were processed to create images of the Morrow stratigraphic surfaces. The P and S-wave images created at each test well were directly compared with Morrow log data and other depth-based engineering data available from each respective test well for imaging verification.

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Results/Accomplishments

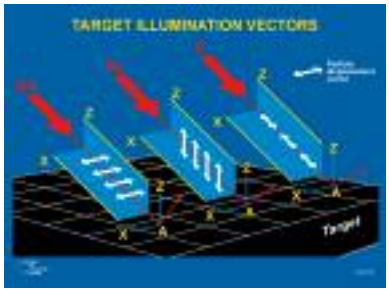
Analysis of the 9-C VSP data confirmed that S reflections were often occurring at different stratigraphic surfaces than were P reflections, providing a greater variety of surfaces for mapping. This reflectivity behavior resulted in improved stratigraphic interpretations of Morrow prospects. The combined P and S images were found to give improved and more detailed indication of Morrow reservoir architecture than the conventional P-waves alone.

The application of 9-C VSP imaging has demonstrated that Morrow reservoir targets generate good-quality S-wave reflection events, supporting the premise that multi-component seismic technology can be utilized for improved stratigraphic identification and reservoir characterization. Results of this project indicate that both P and S-wave seismic data should be acquired for Morrow prospects rather than P-wave only data to improve reservoir identification, whenever economically justifiable.

Benefits/Impacts

The success in identifying Morrow stratigraphy has resulted in continued development and commercialization by Vecta Technology. Through its ongoing research program with the BEG, Vecta is perfecting and commercializing onshore multicomponent seismology. The new technology is roughly twice the cost of conventional 3-D seismic data acquisition, however, it is expected to greatly reduce drilling risks, result in more discoveries, and improve the recovery of bypassed oil, thereby significantly offsetting the higher initial cost.

The use of shear wave data is a breakthrough that can be applied to other reservoirs where P-wave data are inadequate. The recording and interpretation of P, SH, and SV images provides the geoscientist with much more information about subsurface geology, stratigraphy, lithological distributions, and pore-fluid properties than is available from a conventional 3-D seismic program. 9-C VSP technology is expected to produce images showing the more porous sections of rock formations where oil deposits are located. The technology is also expected to enhance fracture identification and to allow operators to image compartmentalized areas of reservoirs where bypassed oil remains. Vecta and the BEG consider 9-C seismic technology to be a major advance in stratigraphic imaging similar to the 3-D seismic breakthrough made 20 years ago for imaging structural traps. Wide-spread industry acceptance and application of surface recorded 9-C VSP data onshore could result in the discovery of significant additional oil reserves across the oil-producing regions of the United States.



9Comp04

Right, directional movement of wave modes; left, three vibrators at a Morrow test site.

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TOTAL ESTIMATED COST

$156,000

COST SHARING

DOE	- $66,000
Non-DOE	- $90,000

WEBSITE

www.netl.doe.gov